Chapter 7 Physics

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1 Chapter 7.1

1.1 Emission Absorbtion Spectra, and Energy Levels

When white light from the sun passes through a prism, the light is dispersed into a continuous spectrum. Substances emit light when they are supplied with energy to heat them. Each element will have its own emission spectrum.

This can be done by passing a large potential difference across the two electrodes in a tube. Examination of the light with a spectroscope shows the emission spectrum is made up of a few specific wavelengths.

If broad spectrum of white light is passed through a sample of gaseous molecules of an element, light of certain wavelengths will appear to be 'missing'. This pattern of lines is identical to the same element's emission spectrum.

1.2 Photons

All electromagnetic radiation travels in discrete energy packets called photons. This means that the transfer of energy is not continuous. The term quantum is used to describe the smallest possible quantity of any energy.

The energy carried by one photon depends only on its frequency, f, as follows:

$$E = hf$$

The value of h, plank's constant, is 6.63×10^{-34}.

The equation above may also be written as:

$$\lambda = \frac{hc}{E}$$

1.3 Transition between energy levels

The emission of a light photon transfers energy away from the atom, meaning that the energy within the atom must have decreased. As energy can only be released in the form of photons, energy can only be emitted from atoms in **discrete** amounts. Therefore, the emission of a photon must be when an electron changes from precise energy level to another precise energy level.

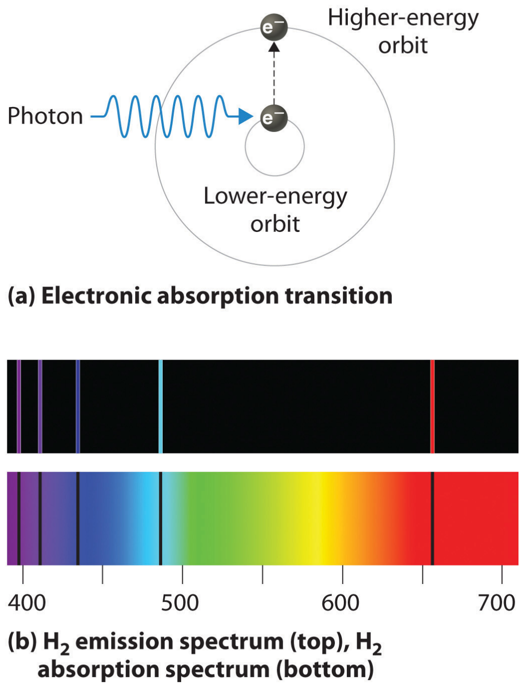

Figure 1: Emission and absorption spectra

The emission of photons of different energies must mean that each atom has many possible energy levels. If there is a difference in energy,

1.4 Nuclear stability

The change to a more stable nucleus is equivilant to a decrease in the nuclear potential energy, and an increase in kinetic energy.
The relative sizes of the coulomb repulsion and the attractive strong nuclear fore depends on the ratio of neutrons to protons.
In large nuclei, (where Z ¿ 82), the nucleaus is unstable, as the repulsive electromagnetic forces are greater than the strong nuclear forces.

Where A ¡ 20, the N/Z ratio is best when at 1:1.
Where A ¿ 20, the N/Z ratio is best when at 3:2.
In order to become more stable, nuclei release radiation in the form of small particles. This is known as ionising radiation, as it causes the particles it interacts with to gain or lose electrons. This is known as **transmutation**.

1.5 Background Radiation

Traces of radioactive isotopes occur naturally in almost all substances. When nuclear radiation enters a detector, it is usually detected as a single event, and these events are counted. This is background radiation, and it is unavoidable. It may be at higher or lower levels depending on surroundings.

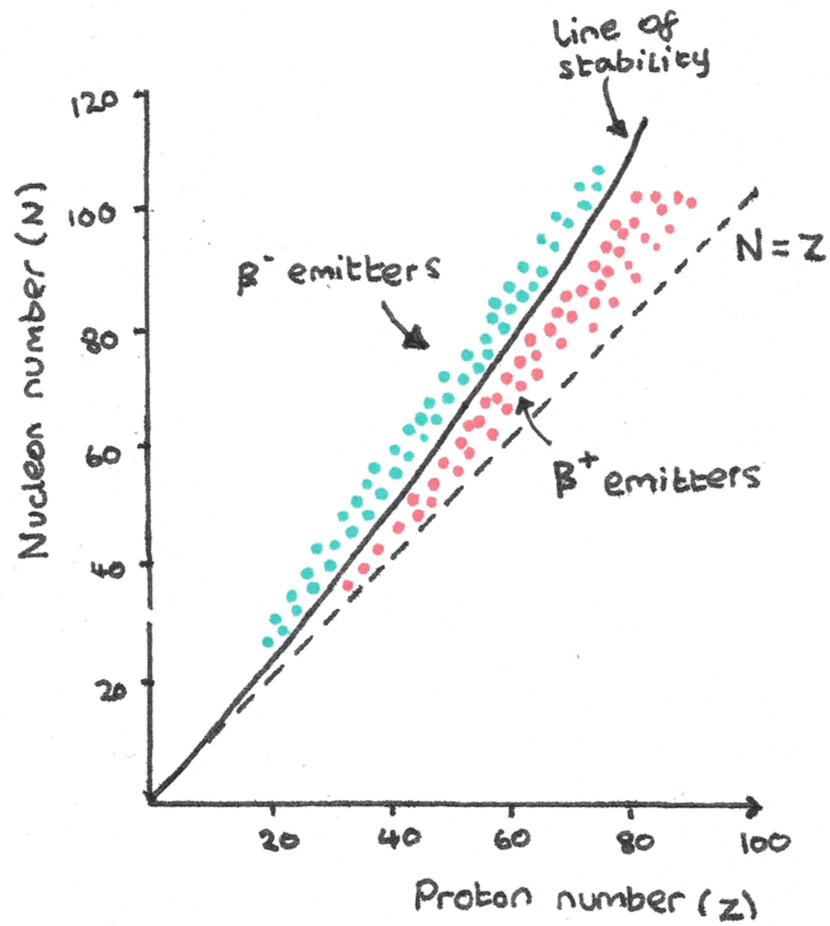

Figure 2: Too many neutrons $= \beta$-$.Toomanyprotons = \beta^{+}$.

1.6 Types of Radiation

1.6.1 Alpha

Alpha particle is the same as the nucleus of a helium-4. ${}^{4}_{2}\alpha ={}^{4}_{2}$ He
${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}\, Y + {}^{4}_{2}\, He$ Nuclear equations must balance, the total neutrons and protons must be the same on either side.

1.6.2 Beta minus radiation

It is possible for an uncharged neutron to be converted into a proton and an electron. It also creates an antineutrino ($\bar{\nu_e}$)
${}^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e + \bar{\nu_e}$

The newly formed electron is ejected at very high velocity.

${}^{A}_{Z}\text{X} \rightarrow {}^{A}_{Z+1}X + {}^{0}_{-1}e + \bar{\nu_e}$

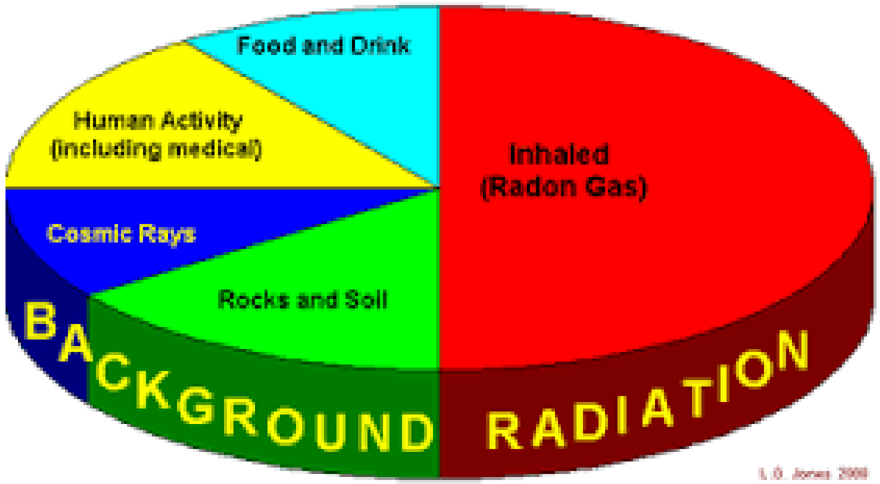

Figure 3: Sources of background radiation

1.6.3 Beta plus radiation

Here, a proton is converted into a neutron and a positively charged electron, a positron. (This too is ejected). A neutrino is also created:

$^{1}_{1}p \rightarrow ^{1}_{0}n + ^{0}_{+1}e + \nu_e$

1.6.4 Gamma radiation

These are high frequency, high energy electromagnetic radiations released from unstable nuclei.

Thorium-234 is formed from uranium-238. The thorium nucleus contains excess energy, (it is in an excited state), so releases gamma radiation to become more stable.

1.7 Deflecting radiation in fields

As $\alpha and \beta particlesarecharged, theycanbedeflectedwhenpassingthroughamagneticfield. \gamma radiationwillnotbedeflected. Flem$

$(Chapter5) Theradiusofthepathofachargedparticlethroughamagneticfieldiscalculatedas : \frac{mv}{qB}$

Figure 4: Alpha particles have roughly 8000 times the mass and twice the charge of a beta particle. Beta moves roughly ten times faster.

1.8 Absorption characteristics of decay particles

Alpha particles are absorbed by a few cm of air particles.
Beta can ionise for up to 30cm. Gamma 'goes' very far, as it has a very low ionising power.

As alpha and beta particles travel through air, they collide with atoms, causing them to lose electrons. The ion and electron that result from this collision are called ion pairs. When the KE of the radiation particle is reduced to a low value, it will stop moving, and is considered 'absorbed'.

The production of ion pairs requires energy. α particles are very large, so transfer energy efficiently. This means that they have a very low penetrating power, but high ionising power.
Beta particles are much smaller, therefore less energy is transferred in a collision, so fewer ion pairs are produced. They therefore have a higher penetrating power, but a lower ionising power.

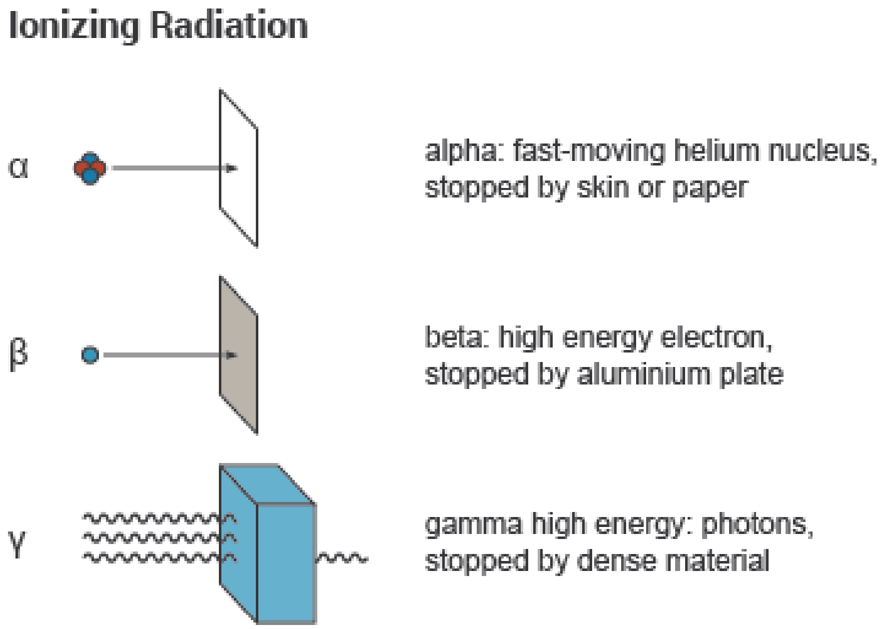

Figure 5: What is needed to 'stop' the types of radiation

2 Section 7.2

2.1 Unified atomic mass

The unified atomic mass, u, is the unit used for mass on a microscopic scale. The unified atomic mass is defined as $1\frac{}{12ofthemassofacarbon-12atom.1u=1.66054\times10^{-22}kg}$

The particles in an atom expressed in terms of u are:

$$proton : 1.007276uneutron : 1.008665uelectron : 0.000549u$$

2.2 Relativity

Einstein's theory of relativity states that energy and mass are different manifestations of the same thing.